Information Sharing and Oligopoly Pricing: A Natural Experiment in Retail Gasoline*

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Abstract

This paper uses a natural experiment from an antitrust case in retail gasoline to study how information sharing affects oligopoly pricing. Empirically, we find that price competition softens when, as part of the case settlement, a firm loses access to high-frequency rival price data from an information sharing platform. We suggest that this finding can be explained by a case-induced change to price commitment under strategic complementary. The analysis has implications for the design of price transparency policies and for understanding of the role that platforms play and their potential effects on competition.

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1 Introduction

Price comparison platforms are revolutionizing many markets by making price data available to consumers. A popular view among governments, which often support such platforms, is that they empower consumers with information to help them search for and find lower prices, thereby promoting competition. Indeed, extensive literature theoretically and empirically confirms the pro-competitive effects of reducing buyers' search costs (Fisher-Ellison, 2016). However, in some cases, the same innovation that reduces consumer search costs also improves information sharing among firms, allowing them to monitor and react to each other's prices, which facilitates collusion. These long-held competitive concerns date back to Stigler (1964), yet there remains little theory and evidence on how information sharing affects firms' conduct.

In terms of theory, in dynamic environments, predicting how improved information sharing will affect firms' strategies and equilibrium outcomes has proven challenging (Asker et al., 2020). Empirically, with rollouts of information-sharing platforms across markets worldwide, one might naturally think there are many opportunities to build an evidence base to inform theory. However, empirical investigations typically face at least one of two fundamental challenges. First, platform rollouts simultaneously affect consumers' and firms' information sets, and consumer search data is often unobserved or poorly measured, making it hard to disentangle how supply-side platform-enabled information sharing among firms affects conduct separately from the impact of demand-side changes in consumer search behavior. Second, while rich price data may be available after a platform is rolled out, baseline price data from before a rollout is often unavailable or insufficiently rich to identify how firms' conduct changes with platform-enabled information sharing.

The antitrust settlement in the *Informed Sources* matter created a natural experiment that allows us to overcome these challenges and identify the impact of information sharing on oligopoly pricing. We describe the *Informed Sources* case, which involves retail gasoline, in Section 2. Our research design leverages three key case outcomes. First, the central case outcome is a shock to information-sharing among oligopolists: before the case, firms shared nearly perfect price information through a platform supported by a company called Informed Sources; but after the case, one of the largest firms was no longer present on the platform and so lost the ability to observe rival price information at high frequency. Second, after the case, the platform collected the prices of the removed firm and shared those prices with rivals. Third, there was no change to the consumer search environment after the case because consumers never had access to the platform, and no other platforms entered or exited before or after the case.

We exploit these three case outcomes to isolate the impact of information sharing on firm conduct. Specifically, we obtain complete, daily station-level pricing data from the Informed

Sources platform before and after the case. We describe these data in Section 3. Combined with the case-induced shock to information sharing, these rich data enable a high-frequency event study design for estimating information sharing impacts on pricing. We estimate these impacts separately for each firm in the market, thus allowing us to characterize how the equilibrium changes with the information-sharing environment.

Section 4 presents our results. Our overarching finding is that pricing becomes *less* competitive with the removal of a firm from the platform and that the removed firm leads this change in conduct. Section 5 provides theoretical intuition for this result. We emphasize that the inability of the removed firm to react to rivals at high frequency once it is off the platform creates a form of price commitment. Under strategic complementary, which retail gasoline pricing is a classic example of, such price commitment leads to higher prices in equilibrium. We summarize and conclude in Section 6, focusing on our results' policy implications and ways forward for research on information sharing and oligopoly pricing.

2 Informed Sources case

Our study centers on Informed Sources (https://informedsources.com/), an international data and analytics company in the retail gasoline sector emphasizing:

> *"Accurate, reliable, timely data ... To make decisions with confidence, you need a complete view of the market."*

The company, which has been in operation for more than 30 years,[1] provides a platform that enables information sharing among gasoline retailers. That is, the platform is historically available to the supply side of the market, but *not* the demand side. Specifically, subscribers to the Informed Sources platform: (1) digitally provide their station-level price data every 15 or 30 minutes to the platform; and (2) gain access to all prices provided to the platform at all times. In addition, as we will see below, Informed Sources complements this information with non-subscriber station-level price data that the company collects manually at daily, weekly, or other frequencies.

2.1 ACCC case

In August 2014, the Australian Competition and Consumer Commission (ACCC) alleged that Informed Sources and Australia's five major gasoline retailers – BP, Caltex, Woolworths, Coles,

[1] "Informed Sources was founded in 1987" (https://informedsources.com/about-us/).

and 7-Eleven[2] – violated section 45 of the Competition and Consumer Act of 2010, which makes illegal "contracts, arrangements or understandings that have the purpose, effect, or likely effect of substantially lessening competition." At that time, all five retailers were subscribers to the platform, and they operated and set prices for more than two-thirds of the stations nationwide (ACCC, 2018), underpinning the government's concerns about anticompetitive outcomes from information sharing. In the words of ACCC Chair Rod Sims,

> *"The ACCC alleges that the arrangements were likely to increase retail petrol price coordination and cooperation, and were likely to decrease competitive rivalry."*
>
> [...]
>
> *"The ACCC alleges that fuel retailers can use, and have used, the Informed Sources service as a near real-time communication device in relation to petrol pricing. In particular, it is alleged that retailers can propose a price increase to their competitors and monitor the response to it. If, for example, the response is not sufficient, they can quickly withdraw the proposal and may punish competitors that have not accepted the proposed increased price."*
>
> - Rod Sims, ACCC Chair, August 20, 2014.

The case was alleged in the retail gasoline market of Melbourne, a major metropolitan area with 4.4 million people in 2017. The ACCC alleged that "the price information exchange service allowed those retailers to communicate with each other about their prices, and had the effect or likely effect of substantially lessening competition for the sale of petrol in Melbourne" (ACCC, 2014). The government further emphasized potential consumer harm, noting that "even a small increase in petrol pricing can have a significant impact on consumers overall. For example, if net petrol prices increase by 1 cent per litre over a year, the loss to Australian consumers would be around $190 million for the year" (ACCC, 2014).

2.2 Case outcomes

The case lasted 16 months, ending with a settlement in December 2015. Two key outcomes emerged from the settlement:

[2]Formally, the trading names of the retailers involved were BP Australia Pty Ltd, Caltex Australia Petroleum Pty Ltd, Woolworths Ltd, Eureka Operations Pty Ltd, and 7-Eleven Stores Pty Ltd. Woolworths and Coles also both operate major supermarket chains and offer gasoline price discounts if consumers' purchases are sufficiently large on a given visit to a supermarket. Since 2013, the federal government has regulated tied discounts to a maximum of 4 cents per litre (cpl) (ACCC, 2013). 7-Eleven operates a chain of convenience stores nationwide with and without associated gasoline stations and offers a loyalty card that provides 2 cpl discounts.

1. Coles would withdraw from the Informed Sources platform when their contract expired four months later in April 2016 (ACCC, 2015a). At this point, Coles lost access to high-frequency price data on its four major rivals, BP, Caltex, Woolworths, and 7-Eleven, which all remained on the platform.

2. Informed Sources would make its data available at reasonable prices to third parties, including third-party consumer search app developers and research organizations (ACCC, 2015b).

The settlement outcomes intended to affect price information on the supply and demand side of the market. In particular, limiting platform-enabled price coordination and enhancing consumer search were meant to promote competition. For example, the ACCC's press release for the settlement stated:

> *"Making [Informed Sources] pricing information available to consumers will allow consumers to make better informed purchasing decisions and therefore create greater competition in petrol pricing."*
>
> - Rod Sims, ACCC Chair, December 23, 2015.

In practice, however, realized changes to the informational environment on the supply and demand side of the market departed in important ways from the ACCC's predictions.

On the supply side, all firms' information over rival prices worsened after Coles exited the platform, with a differential impact on Coles. Our data from the platform, which we describe momentarily, allows us to track how rival price information for BP, Caltex, Woolworths, and 7-Eleven evolved before and after the case. These four firms observed the universe of each other's station-level prices within a given market (city) every 15 or 30 minutes before and after the case.

As we show below, despite Coles' exiting the platform, the remaining four Informed Sources subscribers still observed Coles' prices after Coles exited the platform. However, the frequency and coverage of Informed Sources' data on Coles' stations' prices worsened. In particular, after Coles exited the platform, Informed Sources started collecting Coles' stations' prices using human price spotters. These spotters collected one price observation per station per day for approximately half of Coles' stations in a given city. They mainly collected these data for Coles' stations in the urban core, not the outer suburbs. Our dataset contains all of these aspects of price information from the Informed Sources platform.

Coles likewise observed rivals' station-level prices every 15 or 30 minutes while on the platform. Unfortunately, our Informed Sources data do not reveal Coles' rival price information after it exited the platform. Given the speed and coverage of Informed Sources in generating 15 or 30-minute station-level data for the four remaining subscribers after the case, plus Informed

Sources' intensive daily price spotting of Coles stations, we believe that it is safe to assume that Coles was at an informational disadvantage relative to its rivals in terms of the frequency and coverage of rival price data after it exited the platform.[3]

On the demand side, there was virtually no change in third-party consumer app availability in the year after the Informed Sources case. Appendix A provides details on the history of consumer search apps in Australia, their (lack of) popularity, and lack of change in their availability before and after the case. In this sense, the second key case outcome did not result in a significant change in app-enabled consumer search. This outcome is critical for our analyses of information sharing and oligopoly pricing because there is little change in consumer search (or any other demand shocks) before and after Coles exited the platform.

3 Data

For our analysis, we obtained Informed Sources data on daily station-level prices for Melbourne (4.7 million people in 2017), where the case was alleged. We also obtained data from Sydney (5.1 million people). While the case was not alleged there, we can validate in Sydney whether similar conduct changes occurred after the case when Coles dropped off the Informed Sources platform nationwide.

Our Melbourne sample spans two years, from August 1, 2015, to August 1, 2017, while our Sydney sample spans one year, from August 1, 2015, to August 1, 2016. Both sample windows include the April 2016 period when Coles dropped off the Informed Sources platform. We truncate Sydney's sample because the New South Wales government launched a real-time gasoline price transparency platform called FuelCheck (https://www.fuelcheck.nsw.gov.au/) on August 1, 2016, which drastically changes Sydney's market environment.[4] In contrast, Melbourne does not experience such major shocks to market structure after the Informed Sources settlement. Given Melbourne is where the case was alleged and has a long stable period for evaluating case impacts, our empirical analysis below mainly focuses on Melbourne.

We also collect daily data on wholesale terminal gate prices (TGPs) for Melbourne and Sydney from the Australian Institute of Petroleum (https://www.aip.com.au/). TGPs are the main

[3] We can think of at least two data sources Coles could immediately access after it exited the platform. First, Coles could have their employees at gasoline stations or supermarkets engage in price spotting of nearby competitors and upload their data to Coles's central database. Second, MotorMouth and PetrolSpy, gasoline consumer search apps established in July 2013 and September 2014, could have been monitored by Coles. We describe these apps in Appendix A, noting they provide limited coverage of stations day-to-day and with daily lags in price data.

[4] Specifically, the launch of FuelCheck dramatically changes the informational environment in Sydney. On the market's supply side, real-time station-level data become available to all gasoline retailers, including the five major retailers, smaller retail chains, and independent station operators. On the demand side, the platform has proven popular with consumers in the state, with high adoption rates.

Table 1: Summary Statistics

	Melbourne				Sydney			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Prices (cpl)								
Price	121.3	10.4	92.1	149.9	119.5	12.9	88.9	156.9
Terminal Gate Price	110.1	6.5	95.2	124.5	108.5	7.3	95.7	124.9
Margin	11.3	8.0	-11.9	39.3	11.2	9.8	-13.1	44.2
Panel Dimensions								
Dates	731				397			
Stations								
BP	124 (18%)				64 (13%)			
Caltex	91 (14%)				102 (20%)			
Coles	147 (22%)				59 (12%)			
Woolworths	93 (14%)				44 (9%)			
7-Eleven	145 (22%)				128 (25%)			
Other	74 (11%)				113 (22%)			
Total	674 (100%)				510 (100%)			
Observations								
Electronically collected	324,733 (81%)				128,562 (84%)			
Manually collected	75,598 (19%)				24,306 (16%)			
Total	400,331 (100%)				152,868 (100%)			

time-varying component of stations' daily marginal cost of gasoline. As reflected in the Singapore MOGAS 95/92 index, world oil prices and regional refining market conditions drive daily fluctuations in the TGPs.

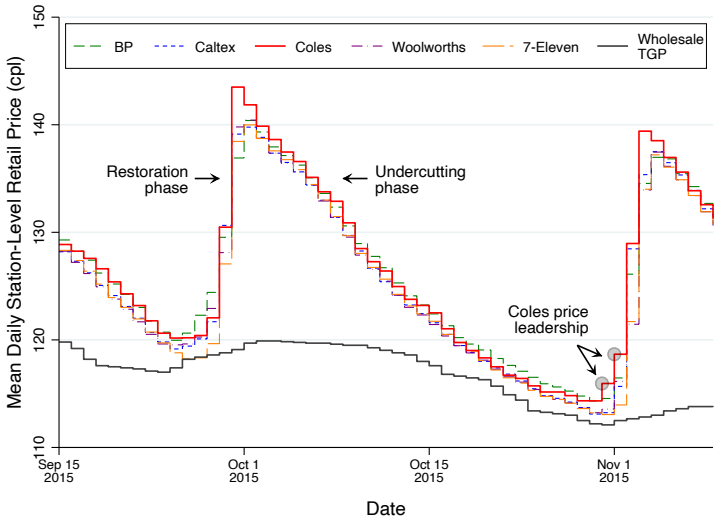
3.1 Descriptive statistics

Table 1 presents summary statistics for our Informed Sources sample. The top panel shows that average station-level prices, costs, and margins (measured in cents per liter or cpl) are similar across the two markets, with margins representing a 10–11% markup over the wholesale TGP.

The bottom panel describes our unbalanced panel's structure. Like many urban retail gasoline markets worldwide (Eckert, 2013), Melbourne and Sydney have asymmetric market structures, with the five major retailers operating the majority of stations and a competitive fringe of smaller retail chains and independents ("Other" stations group in the table). In Melbourne, the dominant retailers are 7-Eleven and Coles, who operate 22% and 20% of the stations in the Informed Sources data. Sydney's dominant retailers are 7-Eleven and Caltex, which operate 24% and 20% of stations.[5]

[5]These market structure figures use data only from stations where Informed Sources collects data. It may miss, in particular, smaller independent stations that Informed Sources deems not worth manually collecting data. How-

Figure 1: Example Retail Price Cycles in Melbourne



The last three lines of Table 1 tabulate *how* each daily station-level observation is collected. The majority of observations are electronically collected (81% and 84% for Melbourne and Sydney, respectively) from the five major retailers, which automatically upload their prices to the Informed Sources platform as subscribers. There is, however, a non-negligible share of daily station-level prices (19% and 16%) that Informed Sources manually collects. These include prices at many of Coles' stations after Coles exits the Informed Sources platform. Below we return to the evolution of electronic and manual price reporting, particularly once Coles is off the platform.

3.2 Price cycles

Retail prices exhibit an asymmetric price cycle in Melbourne and Sydney.[6] Figure 1 illustrates this by way of example, plotting average daily retail prices by retailer for September 1 to November 7, 2015, in Melbourne. Prices infrequently exhibit large jumps which restore profit margins (the *restoration* phase) with regular daily price undercutting in between the jumps (the *undercutting* phase). While Figure 1 plots retailer-level cycles, similar cycles exist at the station level.

Figure 1 illustrates two other key aspects of price restorations. First, restorations tend to occur as retail prices approach the wholesale TGP and margins go to zero. Second, individual retailers often exhibit small average price jumps in the days just before all retailers restore their

ever, using FuelCheck data for Sydney from September 1, 2016 (right after FuelCheck was launched and at the end of our Sydney sample), we can assess the share of missing stations in the Informed Sources data. These data reveal 611 stations in Sydney total, with BP, Caltex, Coles, Woolworths, 7-Eleven, and Other station shares of 11%, 17%, 10%, 8%, 21%, and 34%.

[6]Retail gasoline price cycles exist worldwide, including in the United States, Europe, Canada, and Australia (Eckert, 2013).

margins. Figure 1 highlights this with Coles before a market-wide price restoration in November 2015 in Melbourne. These small jumps reflect a subset of a given retailer's stations restoring their prices a few days before the restorations of the remaining stations in their network. In this way, individual retailers, with relatively larger shares of stations within a market, tend to engage in station-level price leadership to coordinate market-wide price restorations, consistent with findings from, for example, Lewis (2012) and Byrne and de Roos (2019).

It is useful for our analysis of conduct before and after the Informed Sources case to classify station-level price restorations and undercutting phases. We use the following classification:

Definition 1.

(i) *A station-level price restoration* occurs on date t if three conditions hold:

1. $p_{it} > p_{it-1}$
2. $p_{it} = max\{p_{it-5}, \ldots, p_{it+5}\}$
3. $p_{it} - min\{p_{it-3}, \ldots, p_{it}\} \geq 10$.

(ii) *A station-level price cycle* begins with a station-level price restoration. We enumerate this as "Day 0" of a station's cycle. Cycle days $1, 2, \ldots$ follow as the undercutting phase until the next station-level price restoration occurs.

(iii) *Station-level cycle length* is the number of dates between station-level price restorations.

In words, a *station-level price restoration* from Definition 1(i) occurs when the station increases its price to a local maximum. Part 1. identifies dates when a station's prices rise. Part 2. creates a moving window that identifies a local maximum in a station's price within a 10-day window around each date t. Part 3. requires a price restoration involving a sufficiently large price increase (at least 10 cpl) from its recent lowest price at the bottom of the previous cycle.[7] Manual inspection suggests that our classification accurately identifies station-level price restorations.[8] The accuracy of our classification scheme reflects the stability of the existence of price cycles throughout our sample period.[9]

[7] This criterion rules out situations where stations slightly increase their prices at the bottom of a cycle and wait for the next market-wide price restoration.

[8] Our station-level price restoration definition is based on daily average prices, which average over hourly price changes within a day from the Informed Sources platform. Given part 3. of Definition 1(i), it is possible that a station could engage in a restoration late in the day in date t, creating a small average price jump between date $t-1$ and t, but a large average price jump between dates t and $t+1$. In this scenario, we would identify date $t+1$ as the restoration date, even though date t is when the restoration occurs. We have checked the robustness of our results to these small errors. In particular, we have considered an alternative classification where we: (1) identify dates where we classify a station-level price restoration on date t according to Definition 1(i) but find a small average price increase on date $t-1$; (2) adjust our station-level price restoration date to $t-1$ from t; and (3) maintain the restoration price for the cycle starting on date $t-1$ as that from date t. These minor adjustments to station-level price restoration dates have virtually no impact on our results below.

[9] Holt et al. (2022) illustrate the effectiveness of threshold-based rules, like those used in Definition 1, for price

4 Price effects of information sharing

The Informed Sources case allows us to study how information sharing affects oligopoly pricing using the shock to Coles' platform access. We begin with Figure 2, which illustrates how the platform's price reporting changes before and after Coles exits the platform. Panels (a) and (c) reveal a sharp and sudden transition from electronic to manual uploads for Coles stations in Melbourne. In particular, in mid-April 2016, daily station-level electronic price uploads for Coles stations drops to zero, while manual daily station-level price uploads jump to 75 per day (63% of all Coles' stations). A second jump in manual data collection for Coles stations occurs in mid-June 2016, rising to 98 stations per day (82% of all Coles' stations).

As shown in panels (b) and (d), Sydney exhibits a similar shift in Coles data collection in mid-April 2016 when electronic uploads go to zero, and manual uploads simultaneously jump to 33 stations per day (58% of all Coles' stations). The timing of the electronic to manual data collection for Coles in these figures aligns with reports from ACCC (2015a) that Coles ends its contract in April 2016, and that it affects information sharing in cities nationwide.[10]

For *which* Coles stations Informed Sources manually collects data, we show in Appendix B that the platform collects data for stations in the urban core and not the outer suburbs. For example, in Melbourne, the initial 75 stations with manual data collection in April 2016 are in the middle of the city. The platform moves to the city's next suburban "ring" in June 2016 with an additional 23 stations, stopping before the more remote suburbs. Such an inside-out data collection approach likely reflects differences in the value of information for retail price-setting between stations in the urban core with high population density and more local competitors versus more isolated stations in less-dense outer suburbs. In addition, the platform can minimize its per-station manual data collection cost by collecting data for clustered Coles stations along main roads in the urban core and not driving to outer suburbs to collect data from more sparsely distributed stations.

We emphasize the importance of Informed Sources' manual collection of Coles' price data for our study. Without it, we would be unable to examine how Coles' loss of platform access

cycle classification when cycles are stable.

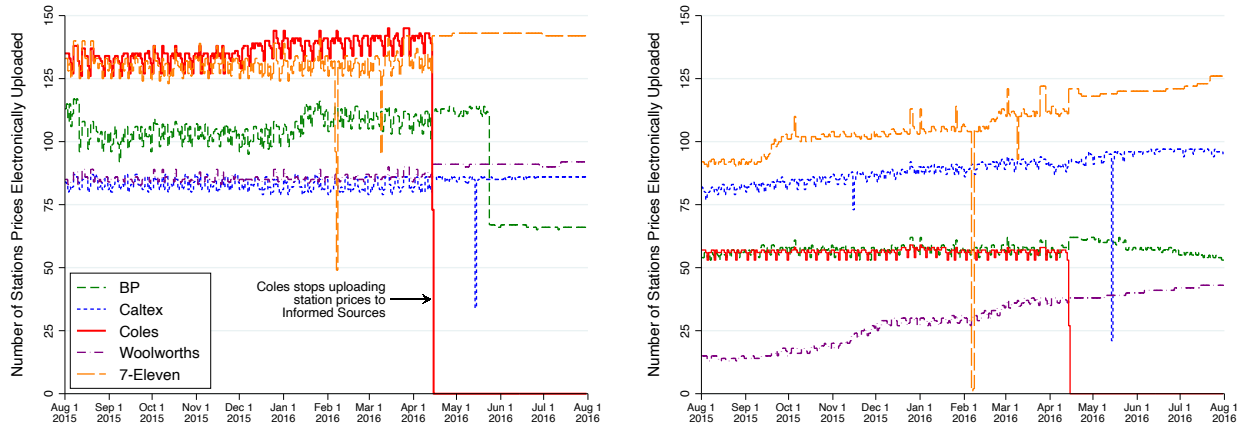
[10] There are three other notable features of the price collection data in Figure 2. First, we see sharp one-day drops in reporting from time to time. Electronic reporting drops likely reflect technical issues, and manual reporting drops correspond to state or national holidays. Second, panels (a) and (c) reveal a simultaneous shift in electronic and manual price uploads for BP stations in mid-June 2016 for Melbourne. There are no public announcements during this period that help explain this shift. It possibly reflects a set of BP-branded independent licensee stations no longer digitally uploading their prices to the platform, with Informed Sources monitoring their prices through manual data collection. Third, before Coles drops off the platform, Informed Sources manually collects data on platform subscribers. After Coles drops off the platform, Informed Sources no longer manually collects data on subscribers. This shift in manual data collection is consistent with Informed Sources substituting its manual data collection workforce from collecting data on subscribers (possibly to validate data digitally uploaded to the platform by subscribers) to collecting daily price data on Coles stations after Coles is off the platform.

Figure 2: Daily Station-Level Price Uploads to the Informed Sources Platform

(Aug 1 2015 – Aug 1 2016)

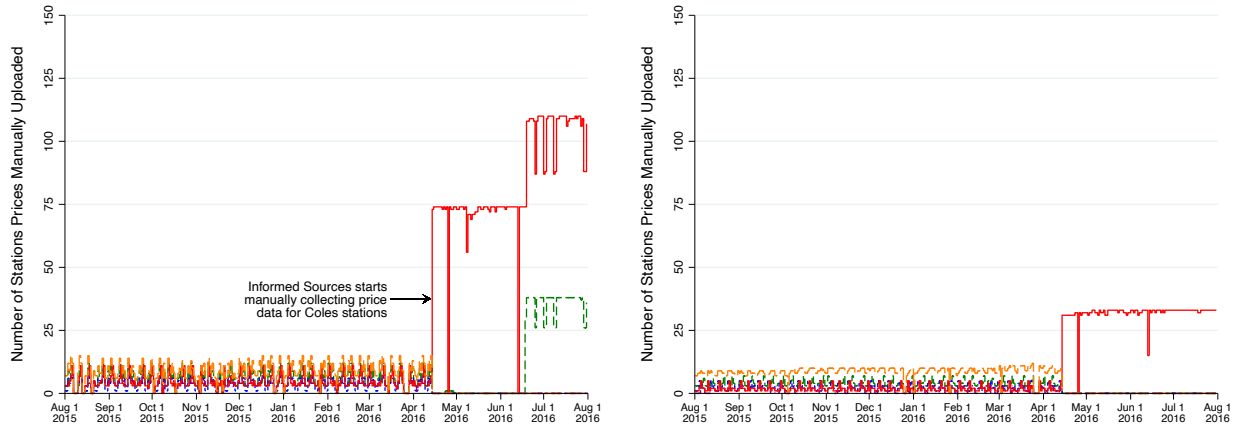
(a) Melbourne Electronic Uploads

(b) Sydney Electronic Uploads



(c) Melbourne Manual Uploads

(d) Sydney Manual Uploads



Notes: Manual uploads drop to zero on two Australia public holidays, namely ANZAC Day and Queen's Birthday.

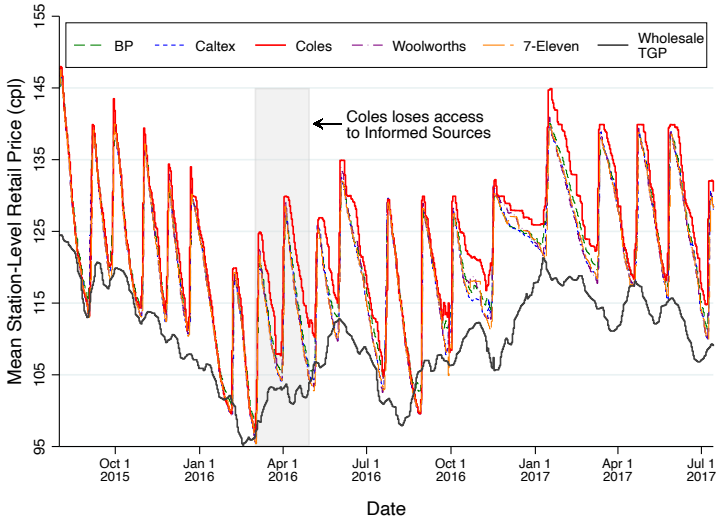
affected the retailer's pricing behavior. To avoid selection bias issues, in all of our analyses below, we only use data for the 75 Coles stations for which Informed Sources collects data both before *and* after the retailer exits the platform. Such issues do not arise for the other four major retailers with digital data collection by the platform before and after Coles exits.

4.1 Graphical evidence of price effects

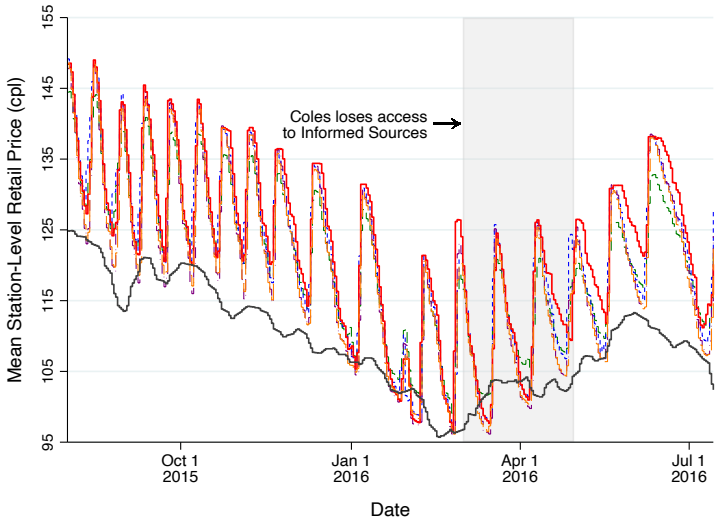
Figure 3 provides preliminary graphical evidence of how Coles' dropping off the Informed Sources platform affects pricing. Panels (a) and (b) plot each retailer's average daily retail price in our Melbourne and Sydney samples. Coles' retail price decouples from its rivals' in March 2016 in both markets, approximately one month before its contract with Informed Sources ends (ACCC,

Figure 3: Retail Price Cycles in Melbourne and Sydney

(a) Melbourne: Aug 1 2015 – Aug 1 2017



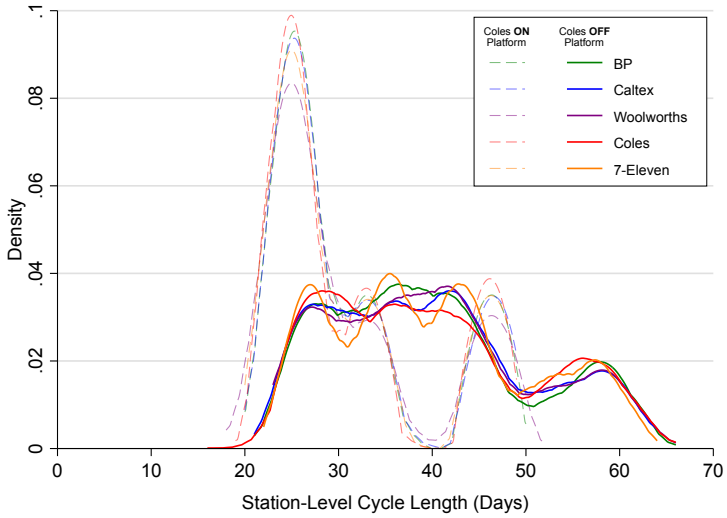
(b) Sydney: Aug 1 2015 – Aug 1 2016



2015a). These patterns are consistent with price effects of Coles exiting the platform in cities nationwide. Visually, Coles' change in conduct is particularly evident during the undercutting phase of the cycle, where it starts pricing at a higher overall level and undercuts less aggressively, particularly after a price restoration. Coles appears to keep its prices at the restoration level longer before following its rivals in undercutting prices.

The figure also shows that the March 2016 timing of Coles' shift in conduct does not correspond precisely to the April 2016 timing in Figure 2 for when Coles stops uploading prices to the

Figure 4: Station-Level Price Cycle Length in Melbourne with Coles On and Off the Informed Sources Platform



Informed Sources platform.[11] In evaluating the longer-run equilibrium impact of Coles losing information-sharing ability on the platform, we will omit dates from our estimation samples for the transition period – March 1 to May 1, 2016 – and check the robustness of our pricing effects estimates to our sample restrictions.

Based on Figure 3, the change in pricing behavior in Sydney following Coles' transition off of the platform appears similar to that in Melbourne. Unfortunately, as alluded to above, we have only three cycles in our sample for Sydney following the Informed Sources case before the New South Wales state government launches its real-time gasoline price transparency website called Fuelcheck, and substantially alters the informational environment for both consumers and firms. Accordingly, the remainder of our investigation focuses on Melbourne, where the case was brought forth by the government and where there is sufficient post-case data to systematically analyze changes in pricing behavior when Coles exits the Informed Sources platform.

4.2 Cycle length

It appears from Figure 3 that undercutting progresses more slowly during the cycles that follow Coles' exit from the platform. Because cyclical restorations tend to occur only once prices have fallen close to cost, it is also evident that the cycles occurring after Coles' exit from the platform

[11] We are not privy to details regarding the contractual relationship between Coles and Informed Sources. However, the timing of the shift in conduct potentially stems from a sunset provision under which Coles loses access to price data on the Informed Sources platform while still having to provide its data within a window of ending its contract with the platform.

take longer to complete.

To better illustrate the change in cycle length, we plot in Figure 4 a kernel density of station-level cycle length (in days) in Melbourne before and after Coles exits the platform. These distributions confirm our visual inspection of Figure 3: price cycle length significantly increases after Coles exits the platform, consistent with a softening of price undercutting.

4.3 Margins

In light of this initial evidence, we now conduct a more thorough analysis of how prices and margins change after Coles exits from the Informed Sources platform. While Figures 3 and 4 suggest that undercutting becomes more sluggish after Coles' leaves the platform, the overall impact on stations' margins is unclear. Margins could be affected by a uniform shift in daily price levels or by a change in shares of days with relatively high or low margins. Therefore, we specify a model of the typical evolution of margins within a price cycle and identify whether margins evolve differently after Coles is no longer on the Informed Sources platform.

We define the margin as the difference between station i's retail price on date t, p_{it}, and the wholesale TGP, c_t. We then estimate the following model,

$$\begin{aligned}\text{margin}_{it} = \beta_0 + \sum_{k=0}^{10} \left[\beta_k \text{CycPct}_{it}^k + \gamma_k \text{ColesOff}_t \times \text{CycPct}_{it}^k\right] \\ + \sum_{\ell=1}^{L} \left[\delta_\ell^+ \Delta^+ c_{t-\ell} + \delta_\ell^- \Delta^- c_{t-\ell}\right] + \eta_i + \nu_d + \lambda_m + \epsilon_{it}. \end{aligned} \tag{1}$$

CycPct_{it}^0 is a dummy variable equaling one if station i has a station-level price restoration on date t ($k = 0$), and CycPct_{it}^k, for $k = 1,\ldots,10$, equals one if station i's cycle day falls within the kth decile of its current station-level cycle length.[12] ColesOff_t is a dummy equaling one if t is after Coles drops off the Informed Sources platform, and η_i, ν_d, and λ_m are station, day of the week, and month of year fixed effects.

We also account for the impact of lagged cost fluctuations on margins in (1). Prices in gasoline markets have been shown to pass through cost changes with a lag, with negative changes passing through more slowly than positive changes (Lewis and Noel, 2011). Therefore, the model also incorporates the potential influence of cost fluctuations on margins by including lagged positive and negative cost changes, $\Delta^+ c_{t-\ell} = \max\{0, \Delta c_{t-\ell}\}$ and $\Delta^- c_{t-\ell} = \min\{0, \Delta c_{t-\ell}\}$.

[12] To take a concrete example, suppose station i on date t has a station-level price restoration, and it is 20 days until its next price restoration. In this case, we would have CycPct_{it}^0=1 and 0 otherwise, CycPct_{it+1}^1=1 and CycPct_{it+2}^1=1 (and 0 otherwise for both), CycPct_{it+3}^2=1 and CycPct_{it+4}^2=1 (and 0 otherwise for both), and so on. If it is 40 days until station i's next price restoration, then we would have CycPct_{it}^0=1 and 0 otherwise, CycPct_{it+1}^1=1 and CycPct_{it+2}^1=1 and CycPct_{it+3}^1=1 and CycPct_{it+4}^1=1 (and 0 otherwise for all), CycPct_{it+5}^2=1 and CycPct_{it+6}^2=1 and CycPct_{it+7}^2=1 and CycPct_{it+8}^2=1 (and 0 otherwise for all), and so on.

The β_k and γ_k coefficients thus quantify average margins immediately following the restoration ($k = 0$) and during each subsequent decile of the undercutting phase ($k = 1, \ldots, 10$), while flexibly accounting for cost fluctuations. These cycle decile dummies allow us to compare the within-cycle evolution of margins across cycles with different lengths before and after Coles is off the platform.

Lastly, the econometric error ϵ_{it} is two-way clustered by station and date to account for unmodeled correlation in margins within a station over time and across stations on a given date. Appendix C provides an extensive set of robustness checks on clustering and inference; all reaffirm our main findings below.[13]

Results

Figure 5 plots the predicted margin charged in Melbourne by stations from each brand during each decile of a cycle's undercutting phase based on the estimated β's and γ's from equation (1 before and after the Informed Sources case. Four key results emerge, which we highlight in the figure. First, restoration margin levels are unchanged, both statistically and in terms of magnitude, before and after Coles exits the platform. After price restorations, firms earn between 21 and 26 cpl, representing a 19% to 24% markup relative to the average wholesale TGP in our sample.

Second, price undercutting softens substantially across all five firms after Coles exits the platform. At every point throughout the undercutting phase, Coles' margins are significantly above their corresponding level from when they are on the platform. Moreover, the margin differences before and after Coles is on the platform are large: relative to when Coles is on the platform, its margins increase by 3.8 cpl 30% of the way through the cycle, 5.8 cpl at 60%, and 4.5 cpl at 90%. Respectfully, these margin increases represent 21%, 63%, and 214% increases relative to baseline levels when Coles is on the platform.

Third, Coles noticeably delays undercutting initially after the restoration once it is off the platform. Panel (c) of Figure 5 highlights this result. Following the platform exit, Coles' prices remain statistically the same as their restoration level until they are 10% of the way through (4 or 5 days) the undercutting phase. From there, price reductions occur but remain sluggish compared to when Coles is on the platform. In contrast, when Coles is on the platform, from the onset of the undercutting phase its margin levels fall immediately and differ statistically from their restoration levels.

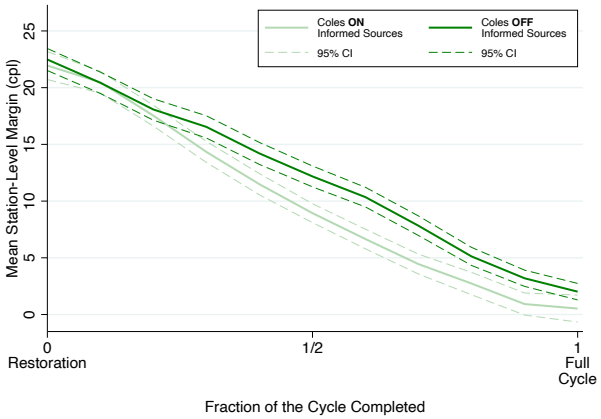
Lastly, there is a substantial change in Coles' pricing behavior at the bottom of the cycle after it exits the platform. Figure 5 shows that all firms cut prices until margins reach 0 cpl

[13] Appendix in progress.

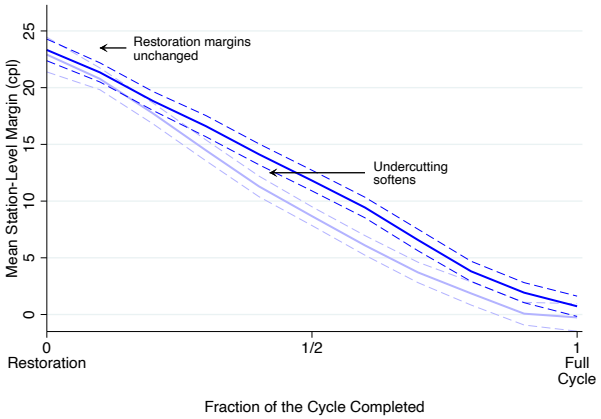
Figure 5: Pricing and Margins Changes by Decile of the Station-Level Cycle when Coles Drops Off the Informed Sources Platform

Melbourne

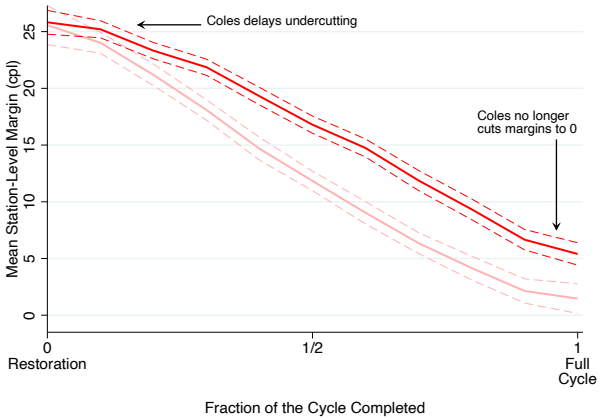
(a) BP



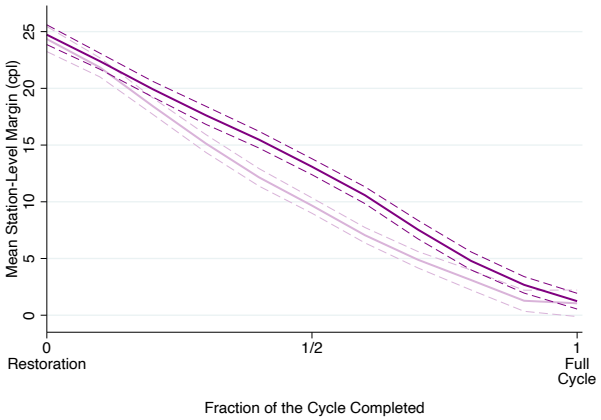
(b) Caltex



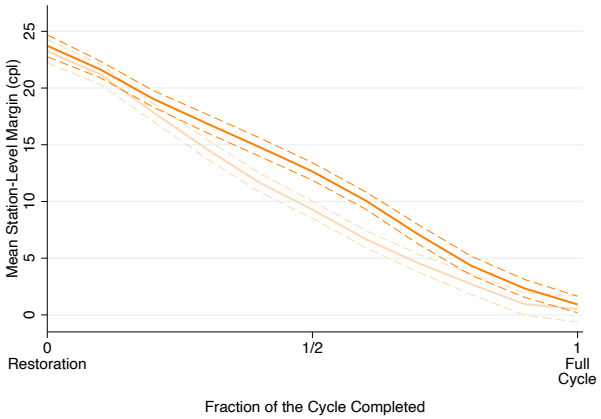
(c) Coles



(d) Woolworths



(e) 7-Eleven



before restoring prices while Coles is on the platform. However, after Coles is off the platform, Coles cuts prices until margins reach 5 cpl. In contrast, all other rivals continue to cut prices until margins approach 0 cpl. For Coles, this represents a substantial percentage increase in margins at the bottom of the cycle from softening price undercutting.

In summary, the results in Figure 5 suggest that Coles shifts the equilibrium to one with the same magnitude of price restorations but with far less aggressive price undercutting after it stops subscribing to Informed Sources. Ultimately, this results in Coles charging higher margins over the entire cycle after it exits the platform. Rivals charge similar prices at the top and bottom of the cycle but charge higher margins for sustained periods during the undercutting phase. Section 5 below explores explanations and implications of this shift in the equilibrium after Coles exits the platform.

5 Explanations and implications of price effects

5.1 An explanation: price commitment

One of our main findings in Section 4.3 is that price undercutting softens and margins rise after Coles exits the platform. In this section, we consider an explanation for this change in pricing behavior, stemming from the effect of the case outcome on firms' rival price information.

With Coles on the platform, all firms have nearly immediate access to information on rival price changes. However, as discussed in Section 2.2, Coles exiting the platform introduces an asymmetry in information sharing across the firms. The four remaining Informed Sources subscribers (BP, Catlex, Woolworths, 7-Eleven) continue to observe each others' prices at high frequency with complete station coverage. Moreover, Informed Sources starts to manually collect daily price data on more than half of Coles' stations in the market's urban core. In stark contrast, Coles completely loses access to rival price data from the platform and is likely not supported by a price-spotting workforce like Informed Sources to collect daily price data on all four rival stations (unlike Informed Sources, which only has to monitor Coles).

In sum, Coles is at a daily informational disadvantage after it exits the platform, working with rival price data with worse coverage that arrives at a slower frequency. As a result, the firm is effectively forced to commit to a price without the ability to monitor and respond to its rivals' price adjustments rapidly. In other words, by exiting the platform, Coles commits to not having the information needed to respond to rivals in the way it previously could.

A natural way to model Coles' change in status is as a shift in the timing of play between Coles and its rivals. With Coles on the platform, all firms have similar high-frequency information on rivals' prices, resulting in a situation resembling simultaneous price setting. With Coles

off the platform, Coles' rivals' can observe Coles' prices and set their prices in response, knowing that Coles is unable to observe and respond to them at a similarly rapid pace. Consequently, Coles takes on a role much like a Stackelberg leader in a sequential pricing game each day. In practice, this typically involves one price change per station per day (ACCC, 2012), with Coles facing, but unable to observe, fast-moving rivals after adjusting its prices.

A key result in oligopoly theory from Gal-Or (1985) is that equilibrium prices rise when an environment changes from simultaneous to sequential timing under price setting if payoffs exhibit strategic complementarity in prices. This theoretical prediction aligns with the shock to the firms' information sets and commitment ability and the subsequent increase in margins induced by the Informed Sources antitrust case. Intuitively, Coles benefits from higher prices set by its rivals. If prices are strategic complements,[14] Coles can induce its rivals to set higher prices by itself, thereby maintaining higher prices.

Interestingly, Brown and MacKay (forth.), in their study of pricing algorithms, obtain a similar intuition from a fully dynamic model of price competition where duopolists choose their pricing frequencies. They show that, under strategic complementarity in prices, equilibrium profits are higher compared to symmetric Bertrand levels when firms either: (1) set prices at asymmetric frequencies; or (2) have an asymmetric ability to commit to prices (e.g., only one firm can commit to future price changes that depend on its rivals' price). These findings of softer price competition under asymmetric algorithms align remarkably well with results from the Informed Sources case. Once Coles exits the platform, it faces new data limitations on rivals' prices that effectively result in it having a slower pricing algorithm than its rivals (who collect relatively richer and higher frequency data from the market to adjust prices more quickly), enabling it to commit to prices that its rivals can observe and respond to. We return to insights into algorithmic price competition from our novel empirical results in Section 6 below.

5.2 Welfare analysis

A second key result from both Gal-Or (1985) and Brown and MacKay (forth.) is that first-movers under sequential price setting lose market share relative to their shares under simultaneous Bertrand pricing. Whether the first movers' profits fall relative to those realized under simultaneous Bertrand is ambiguous, while the second movers' profits always rise. In this section, we empirically investigate these aspects of the Informed Sources case and its impact on consumer welfare, market shares, and profits.

[14] Empirical studies of gasoline demand establish strategic complementarity in price setting. See, for example, Houde (2012) or Levin et al. (2017).

Demand model

Houde (2012) demand model and how we quantify the impact of the case on shares, consumer surplus, and profits here.

Auxiliary data and model calibration

Model estimation/calibration here.

Results

Impact of the case on prices, shares, consumer surplus, and profits here.

6 Conclusion

Prevailing wisdom suggests that competition is likely to soften when competing firms have access to price-sharing platforms that allow them to easily and rapidly observe the prices of their rivals. Leveraging a unique natural experiment, we provide empirical evidence that this may not always be the case, particularly when only a subset of firms have access to the price-sharing platform.

Our investigation studies how gasoline prices change after one major firm (Coles) loses access to a price-sharing platform as part of an antitrust settlement. In a press release announcing the settlement, the Chairman of the Australian Competition & Consumer Commission is quoted as saying that the Commission views removing the firm from the platform "to be an extremely positive step towards increasing competition" (ACCC, 2015a). However, our findings reveal that price margins are higher following Coles' exit from the platform. It is unclear how completely removing the Informed Sources platform would have affected competition as originally intended when the government brought forth the case. However, a compromise that involved removing just one of the firms from the platform weakened competition.

We interpret this outcome as an illustration of the importance of considering how access to information can alter the timing of moves among competitors. Indeed, using an exogenous market shock, our analysis offers a novel causal estimate of the relative competitiveness of sequential versus simultaneous move competition in otherwise identical market environments that harken back to early theories of competition in industrial organization and contemporary models of competition through pricing algorithms. The empirical insights from the antitrust case-induced shock provide a cautionary tale for policymakers considering regulating pricing algorithms and the unintended consequences that can arise if regulation creates asymmetry in the timing of play between algorithms.

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Appendix

A Consumer search apps

Three gasoline price comparator platforms operated in Melbourne during our sample period: MotorMouth, Petrol Spy, and GasBuddy. Our investigation into industry reports and internet archives indicates that these platforms only provided users with limited and lagged price information.

MotorMouth, owned by Informed Sources, started its price monitoring service in Melbourne in 2001. Its price data primarily come from electronic updates from the major retailers and manual collections by drivers employed by the company. The MotorMouth app started to allow app users to collect and confirm prices in February 2016. However, app features were designed to prevent gasoline stations from monitoring each others' prices using the app. At the same time, it was difficult for consumers to compare prices.[15] For example, app users could only see prices at up to 2 "Favorite Stations" in up to 2 "Favorite Locations" as well as the lowest price in the area. If App users wanted to see prices at an additional station, they had to use app credits earned from price collections to unlock the station for a limited period. Following the resolution of ACCC proceedings relating to petrol price information sharing, Informed Sources made its price data available to consumers on its MotorMouth app in May 2016. However, the app features limited price comparison and monitoring. App users had to click "Price Reveal" to see a station's price at a time. Only 30 "Price Reveals" points were available at the start of a week. If one ran out of points during the week, one could top up the quota once by entering an SMS code.

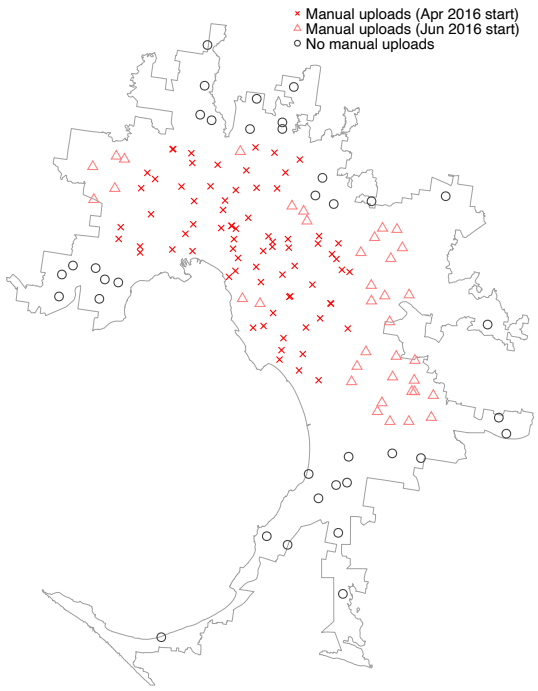
PetrolSpy was launched in 2014 and is the most popular private petrol price search platform in Australia. The app relies on crowdsourcing for its price data. App users can submit and update price changes to earn points to enter into a $25 Fuel Card draw every fortnight. According to the company, it had over 25,000 active users and 2500 price updates daily across all states and territories in Australia in March 2016. There were around 7100 retail petrol sites in Australia and around 2000 petrol stations in Melbourne Metropolitan alone. A back-of-the-envelope calculation suggests that the prices on PetrolSpy were updated at least one day ago on average. GasBuddy launched in Australia in March 2016. However, it did not seem to gain popularity and gradually exited the market. The last Twitter post from its official account, GasBuddy Australia, was from April 2017.

[15] MotorMouth was unpopular among consumers. As of October 26, 2022, MotorMouth was rated 1.9 out of 5 by 134 reviewers in the Apple store. In contrast, NSW FuelCheck was rated 4.7 out of 5 by 67 thousand reviewers.

B Supplemental figures and tables

Figure B.1: Coles Stations that Informed Sources Manually Collected Data On

(a) Melbourne



(b) Sydney

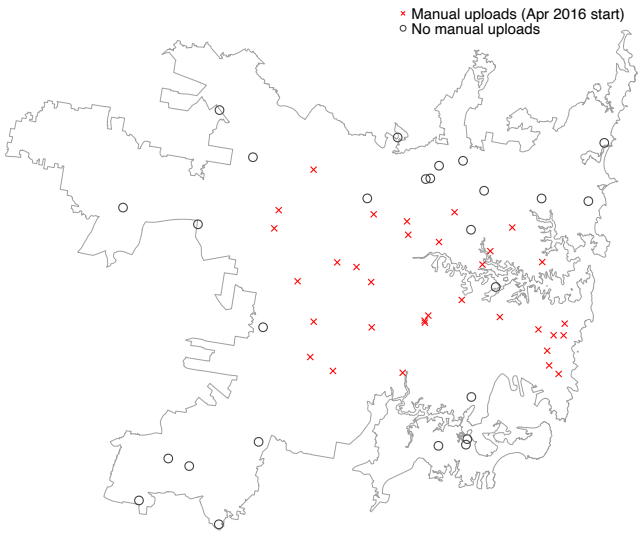
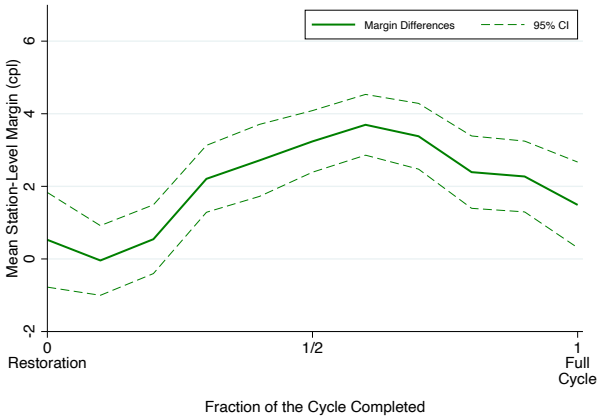


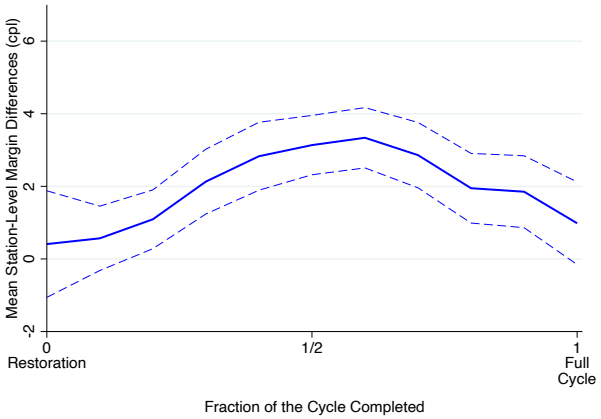
Figure B.2: Margin Differences by Decile of Station-Level Cycle Pre and Post Coles Exits the Informed Sources Platform

Melbourne

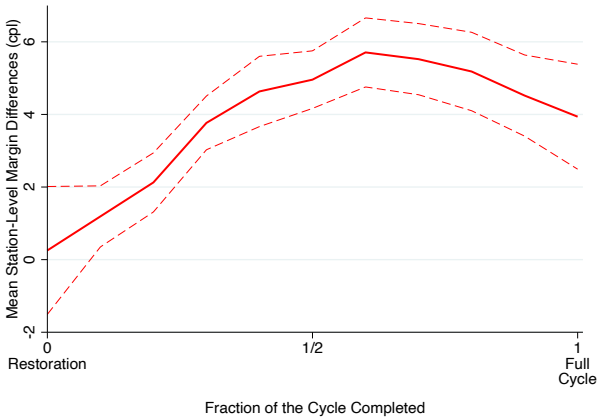
(a) BP



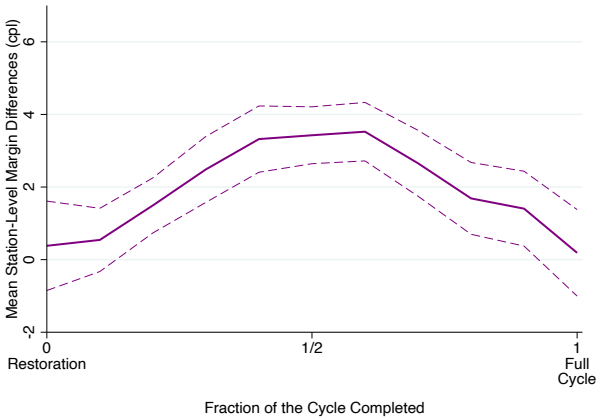
(b) Caltex



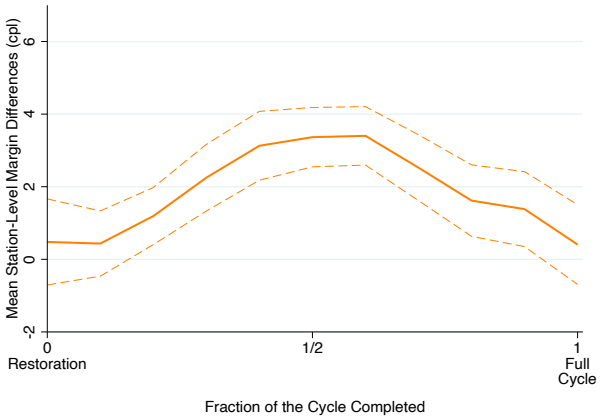
(c) Coles



(d) Woolworths



(e) 7-Eleven



C Clustering robustness checks

[To be completed]

D Demand model calibration details

[To be completed]